Dropping In a Microgravity Environment

2001/2002

for student teams
in Illinois, Indiana,
Michigan, Minnesota,
Ohio, and Wisconsin

Experiment Design Requirements

This document contains the guidelines and requirements for designing a team's experiment apparatus to successfully operate in the 2.2 Second Drop Tower Education Rig.

DIME 2001 team experiment mounted in the Education Rig of the NASA Glenn 2.2 Second Drop Tower Facility

National Aeronautics and
Space Administration
Glenn Research Center

1. Contents

2. Introduction

This document contains necessary requirements for the design and fabrication of a team's experiment apparatus. These requirements are identified by the numbered paragraphs in sections 5 through 8 of this document. Explanatory notes in italics have been included to clarify the intent of a requirement and to provide essential technical information about capabilities of the drop tower and the drop rig.

The applicable requirements must be followed by the DIME team during the design and fabrication of the experiment apparatus. The penalty for not following requirements may be denial of permission to operate the experiment in the drop tower. The consequence of not following requirements may be a non-functional experiment during operations in the drop tower. When changes or improvements are made to the design, check to make sure the applicable requirements are satisfied.

Some of the requirements are optional and may not apply to a team's experiment. For example, if the video data capabilities are not used by an experiment, the requirements pertaining to the video camera and video recording do not apply.

The size of this document may seem daunting to a DIME team, but it contains the information necessary for a team to design an experiment which will operate successfully in the NASA Glenn 2.2 Second Drop Tower. Defining the interface between two pieces of equipment (in this case, the team's experiment apparatus and the Education Rig) is an important engineering function which is utilized by NASA every day. For example, when a company designs a satellite to be mounted inside the Shuttle cargo bay, the interface description between the satellite and the Shuttle cargo bay needs to be exact so the satellite will fit properly and function as desired.

3. Definitions

3.1 *Experiment apparatus* *is the experimental equipment that the DIME team designs and constructs.*

3.2 *Mounting Adaptor Plate* *is an aluminum plate (12 inches X 12 inches X $^{1}/_{2}$ inch) with threaded holes in a rectangular array on which the team's experiment apparatus is attached. NASA provides a Mounting Adapter Plate to each selected team.*

3.3 *Education Rig* *(Figure 1) is the experiment carrier to which the DIME experiment apparatus is mounted using the Mounting Adaptor Plate. The Education Rig contains electrical power supplies, a video camera, and instrumentation to support the experiment apparatus. NASA provides the Education Rig. The dimensions of the experiment area of the Education Rig are in Section 9.*

3.4 *Drag shield* *(Figure 2) is a box which totally encloses the Education Rig. Its function during the drop is to shield the Education Rig and experiment apparatus from accelerations due to air drag. NASA provides the Drag Shield.*

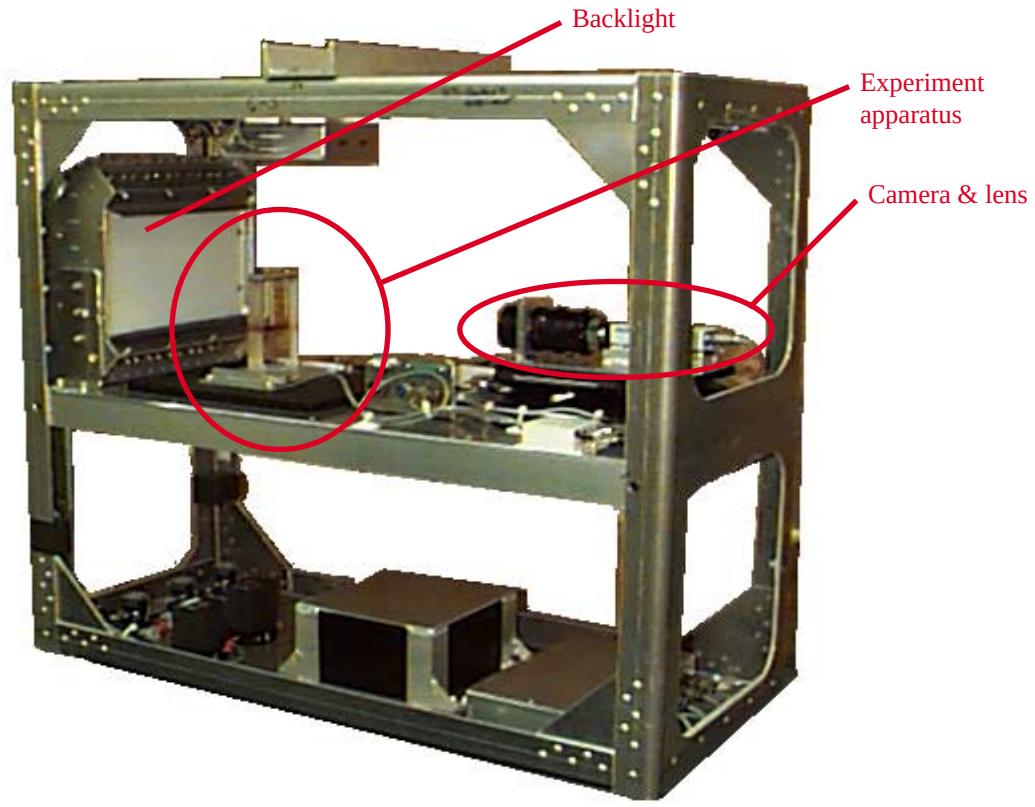


Figure 1. Education Rig with a camera and lens to the right on the middle shelf. The experiment apparatus to the left on the middle shelf is a simple fluid cell. A back-light box is behind the experiment apparatus. The battery, power supply, and relays are mounted on the bottom shelf.

Figure 2. Drag shield being assembled. The Education Rig was previously installed inside the drag shield.

4. NASA-Supplied Equipment

NASA will supply each selected DIME team with the following equipment, as required, to be used in the construction of the team's experiment apparatus.

1. *The Mounting Adaptor Plate[1] measures 12 inches by 12 inches by $^1/_2$ inch (30.54 cm by 30.54 cm by 1.27 cm). It is made of black anodized precision machined aluminum. There is a 12 by 12 matrix of standard $^1/_4$ - 20 threaded holes on 1.00 inch centers. The outer holes are 0.5 inch from the adjacent edge. The Mounting Adaptor Plate weight is 6.8 pounds.*
2. *$^1/_4$ - 20 thread tap (to clean the threaded holes in the Mounting Adaptor Plate)*
3. *Electrical connectors (as required)*
4. *A shipping container will be used to send the Mounting Adaptor Plate to the team. This shipping container must be used to send the finished experiment apparatus to NASA.*

The following equipment will be made available to the DIME teams while in the 2.2 Second Drop Tower for their experiment operations and data analysis.

1. *A computer with data logger software.*
2. *An Education Rig in which the experiment apparatus will be mounted.*
3. *A basic hand-tool kit with wrenches, pliers, sockets, and screwdrivers. The team is responsible for supplying any special tools required by their experiment during Drop Days.*

5. Safety Requirements

The test operations at the 2.2 Second Drop Tower are subject to the Glenn Safety Permit System. The objectives of this system are to avoid undue risks, injury to personnel, damage to property, or disruption of operations. Additional safety concerns may be raised during review of the DIME proposals, the experiment design, and/or the student-built experiment. These issues will be addressed on a case-by-case basis.

5.1 Dangerous or hazardous chemicals (including radioactive materials) or chemical reaction products must not be used in the experiment.

All proposed combustion experiments will be reviewed by a NASA panel on a case-by-case basis. This is not meant to discourage combustion experiments, but rather to ensure safe operations of the experiment and the drop tower.

5.2 Biological samples, for the most part, may not be used in the experiment, except for common household products (e.g. cotton). Live animals, even insects, are not acceptable. All materials will be reviewed by a NASA panel.

5.3 Lasers must not be used in an experiment.

5.4 The maximum voltage allowed in an experiment is 28 volts.

5.5 Any chemicals and all materials must be contained within the experimental apparatus.

5.6 The Safety Documentation supplied with the experiment apparatus must include:

1. Description of the experiment including the objective(s) and what materials, gases, flow rates, pressures, etc. are involved
2. Mechanical documentation needs to include:
    - Technical description of the overall experiment apparatus
    - Description of the major components (including manufacturer and model number of commercial components)
    - Mechanical drawings of the experiment apparatus (including dimensions and labels)
    - Description of design features to ensure survival after impact
3. Electrical schematics (if electrical circuits are used in the experiment apparatus)
4. Step by step procedures for experiment apparatus preparation and drop testing

NASA may request additional information to aid in the evaluation of the experiment during review of the design and review of the safety documentation. NASA has the final authority for safety approval. NASA personnel will inspect the experiment apparatus upon its arrival at Glenn to determine its final suitability. If modifications are still necessary at that time, the team will have an opportunity to make those changes after their team arrives at NASA Glenn.

6. Mechanical Requirements

6.1 The experiment apparatus must be contained within a volume measuring 12 inches by 12 inches by 12 inches (30.54 cm by 30.54 cm by 30.54 cm). The NASA-supplied Mounting Adaptor Plate is included in this volume, see Figure 10.

The control, power, and data connectors and their associated cables which are used to connect the experiment to the Education Rig are not included in the volume above.

6.2 The experiment must be attached to the upper surface of the Mounting Adaptor Plate.

6.3 The fasteners should engage at least $^{3}/_{8}$ inches (about eight threads) to avoid stripping the threaded holes in the aluminum Mounting Adaptor Plate.

The protective black coating on the Mounting Adaptor Plate partially fills the threads of the threaded holes. The NASA-supplied $^{1}/_{4}$ - 20 thread tap should be used to clean a Mounting Adaptor Plate threaded hole before a fastener is inserted.

6.4 The lower surface of the Mounting Adaptor Plate must be kept clear of equipment, including fasteners.

The Mounting Adaptor Plate will be mounted flat on a shelf of the Education Rig. Therefore, the Mounting Adaptor Plate lower surface must be kept clear.

6.5 The four corner holes of the Mounting Adaptor Plate must not be used, see Figure 3.

These four corner holes will be used to mount the experiment apparatus in the shipping container and to mount the experiment apparatus to the drop rig. Therefore, the area above these holes must be kept clear.

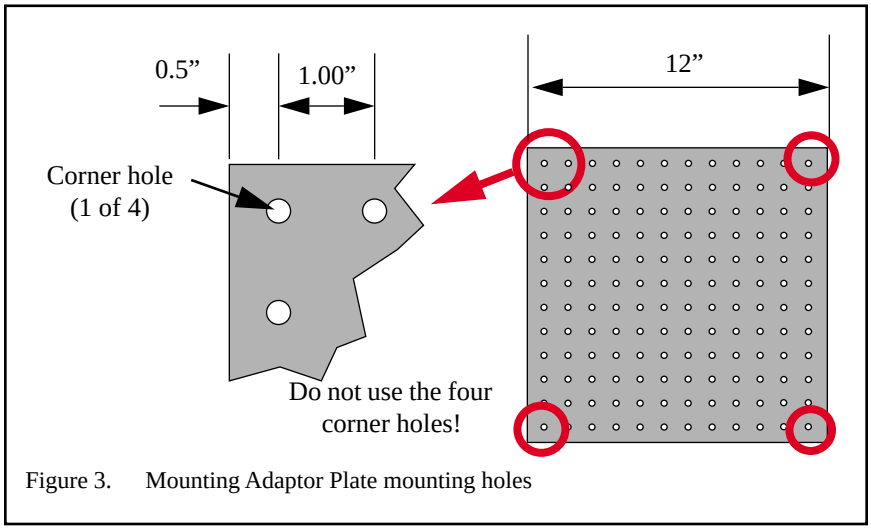


Figure 3. Mounting Adaptor Plate mounting holes

6.6 The experiment apparatus needs to withstand repeated shock loads of 25 g’s (245 m/s^2).

6.7 The mass of the experiment apparatus must be less than or equal to 25 pounds (11.4 kg), including all experiment fluids, cables, connectors, Mounting Adaptor Plate, etc.

7. Electrical Requirements

Electrical connections from the Education Rig to the experiment apparatus are contained in a set of five connectors, see Figure 4. In addition, Figure 9 and Figure 10 show the location of the connector panel on the Education Rig.

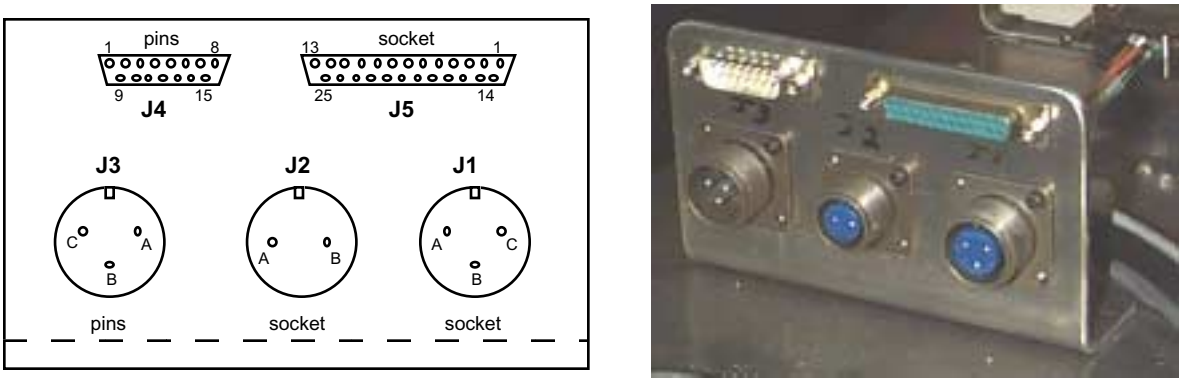


Figure 4. Education Rig connector panel (front view)

Electrical Power Requirements

Note that use of electrical power for an experiment is optional. Examples of electrical power usage in an experiment are shown in Section 11. If electrical power is not used in an experiment apparatus, then skip this Electrical Power Requirements section.

Electrical power is supplied by a 28 volt (nominal) lead-acid battery. Electrical power available at the power connectors will be 28 volt DC (+/- 2 v) from the battery at a maximum of 8 amperes. The 12 volt DC (+/- 0.25 v) from an electronic power converter at a maximum of 1 ampere. NASA will provide to the selected teams the connectors necessary to connect to the Education Rig.

7.1 Sufficient cable length must be provided to allow the connectors to reach the corresponding Education Rig connectors, see Figure 9.

7.2 Wires used must meet National Electric Code standards for both size and insulation.

7.3 An electrical circuit diagram must be prepared and submitted as part of the preliminary design package and the safety package.

7.4 Connections for the 28 VDC Power Connector, J1, must be used as listed in Table 1.

TABLE 1. 28 VDC Power Connector, *J1*, terminal functions

Terminal	Function
A	Connection to the 28 VDC power positive
B	Connection to the 28 VDC power negative (which is connected to a ground common to 12 VDC)
C	Ground

7.5 Connecctions for the 12 VDC Power Connector, J2, must be used as listed in Table 2.

TABLE 2. 12 VDC Power Connector, *J2*, terminal functions

Terminal	Function
A	Connection to the 12 VDC power positive
B	Connection to the 12 VDC power negative (which is connected to a ground common to 28 VDC)

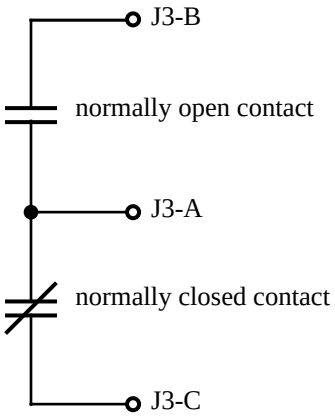
Electrical Control Requirements

Note that use of these control functions is optional. Examples of electrical control in an experiment are shown in Section 11. If electrical control is not used for an experiment apparatus, then skip this Electrical Control Requirements section.

Electrical control of the experiment before it is dropped, at the moment of release, and during the drop is available through two connectors on the Education Rig. One connector is for signal-level purposes and one is for switched power.

7.6 Sufficient cable length must be provided to allow the experiment apparatus connectors to be extended to the connectors in front of the 12 inch x 12 inch footprint of the experiment apparatus in accordance with Figure 9 and Figure 10.

7.7 The Power Switch Relay contacts (Figure 5) provides an electrical signal before the experiment is released for the free fall. Current through the power relay contacts should be limited to 8 amperes. This relay is controlled by an operator with a switch on a console in the drop tower.



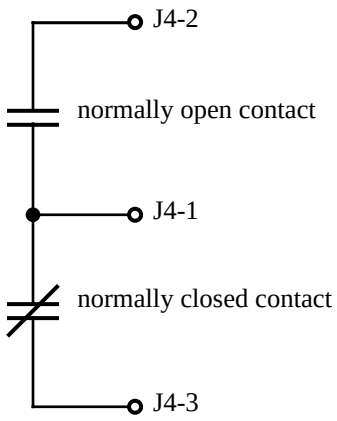
The POWER SWITCH RELAY is controlled by a drop tower staff member with a panel switch. This relay can be turned on and off by using the panel switch before the experiment is released. When the panel switch is DOWN, the relay is OFF (de-energized), and the contacts are in the condition shown in this diagram. When the panel switch is UP, the relay is ON (energized), and the contacts are reversed from the condition shown in this diagram.

After the experiment is released, this relay becomes de-energized and the contacts change back to the condition shown in this diagram.

This set of relay contacts could be used to initiate an action within the experiment before the experiment is released for the free fall. A typical use is for providing power to a heater in an experiment to bring the experiment to a desired temperature before the experiment is released.

Figure 5. Power Switch Relay contact action description

7.8 The Release Indicator Relay contacts (Figure 6) provides an electrical signal at the initiation of the free fall.



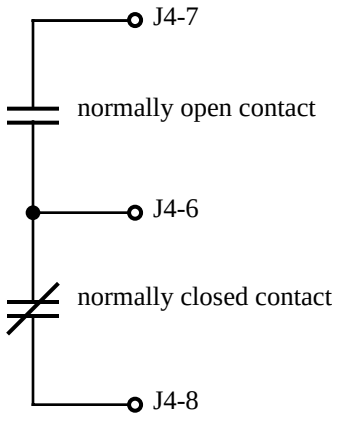
Before the experiment is released to fall in the drop tower, the RELEASE INDICATOR RELAY is energized and the contacts are reversed from the condition shown in this diagram.

Upon release, the relay is de-energized and the contacts change back to the condition shown in this diagram.

This set of relay contacts could be used to initiate an action within the experiment at the very start of the 2.2 seconds of free fall. For example, this signal may be used to energize an electromagnet at the beginning of the free fall.

Figure 6. Release Indicator Relay contact action description

7.9 The Time Delay Relay contacts (Figure 7) provides an electrical signal at an adjustable time during the free fall. This time delay is adjustable by the DIME team as part of their experiment setup.



Before the experiment is released to fall in the drop tower, the TIME DELAY RELAY is energized and the contacts are reversed from the condition shown in this diagram.

The TIME DELAY RELAY has an adjustable time delay (between 0.1 and 102.3 seconds in 0.1 second increments) which the DIME team may set for an appropriate time based on their experiment needs.

After the experiment is released for the free fall, the relay remains energized for the time set by the delay time. After the delay time expires, the contacts change back to the condition shown in this diagram.

This set of relay contacts could be used to initiate an action within the experiment at a time part way through the 2.2 seconds of free fall.

For example, this signal may be used to power a solenoid to pop a balloon during the free fall.

Figure 7. Time Delay Relay contact action description

Data Connections

The drop rig utilizes a Valitec data logger model AD2000[2,3]. The use of the data logger is optional. An example of data logger used in an experiment are shown in Section 11.

A computer with Valitec Configuration & Analysis Software[4] will be made available to the DIME teams while in the 2.2 Second Drop Tower. This computer will be used by the teams to configure the AD2000 data logger characteristics, to extract the data from the data logger, and for data analysis. Teams planning to use the data logger should read the manufacturer's information prior to DIME Drop Days at NASA Glenn.

7.10 Experiment apparatus data connections must utilize a DB-25 pin connector wired in accordance with Table 3, as needed, to plug into the data connector, J5.

TABLE 3. Data Connector, J5, Functions by Terminal[2]

Terminal	Function	Terminal	Function
1	No connection (N / C)	14	N / C
2	Analog Signal Input #8	15	Analog Signal Input #7
3	Analog Ground	16	Analog Signal Input #6
4	Analog Signal Input #5	17	Analog Ground
5	Analog Signal Input #4	18	Analog Signal Input #3
6	Analog Ground	19	Analog Signal Input #2
7	Analog Signal Input #1	20	N / C
8	N / C	21	N / C
9	Digital Input #3	22	Digital Ground
10	Digital Input #2	23	Digital Input #1
11	N / C	24	N / C
12	N / C	25	N / C
13	N / C	-	-

NASA will supply the DB-25 pin connector if a team plans to use the data logger.

7.11 Sufficient cable length must be provided to allow the DB-25 connector to be connected in accordance with Figure 9.

The data logger sample rate is adjustable up to a maximum of 250 samples per second. The experiment apparatus should not generate signals of significant magnitude at frequencies above one-half of the sample rate.

The analog and digital input voltage range is 0 to 5 volts. The analog and digital ground terminals are connected together internal to the data logger.

8. Video Camera Interface

Use of the on-board video camera is optional.

The drop rig camera is mounted on the Education Rig, see Figure 9. The vertical height is adjustable from 4.5 inches to 7.5 inches above the drop rig shelf, see Figure 10. The vertical height is adjusted by the experiment team in the preparation lab before the drop.

The field of view of the video camera is rectangular and centered in front of the camera. The camera has a zoom lens with an adjustable focus. The field of view dimensions are illustrated in Figure 8.

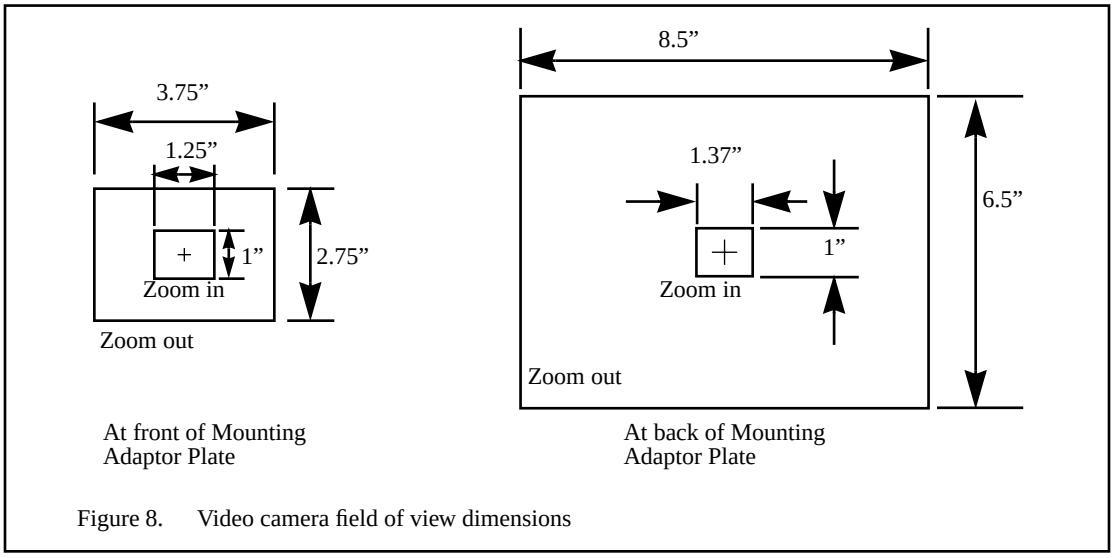


Figure 8. Video camera field of view dimensions

8.1 During installation and setup of the experiment apparatus in the drop rig, the team is responsible for proper adjustment of the camera focus, zoom, and height.

The video data produced during experiment operations will be recorded on video tape recorders in the drop tower facility and will be furnished to the team for analysis.

9. Education Rig Drawings

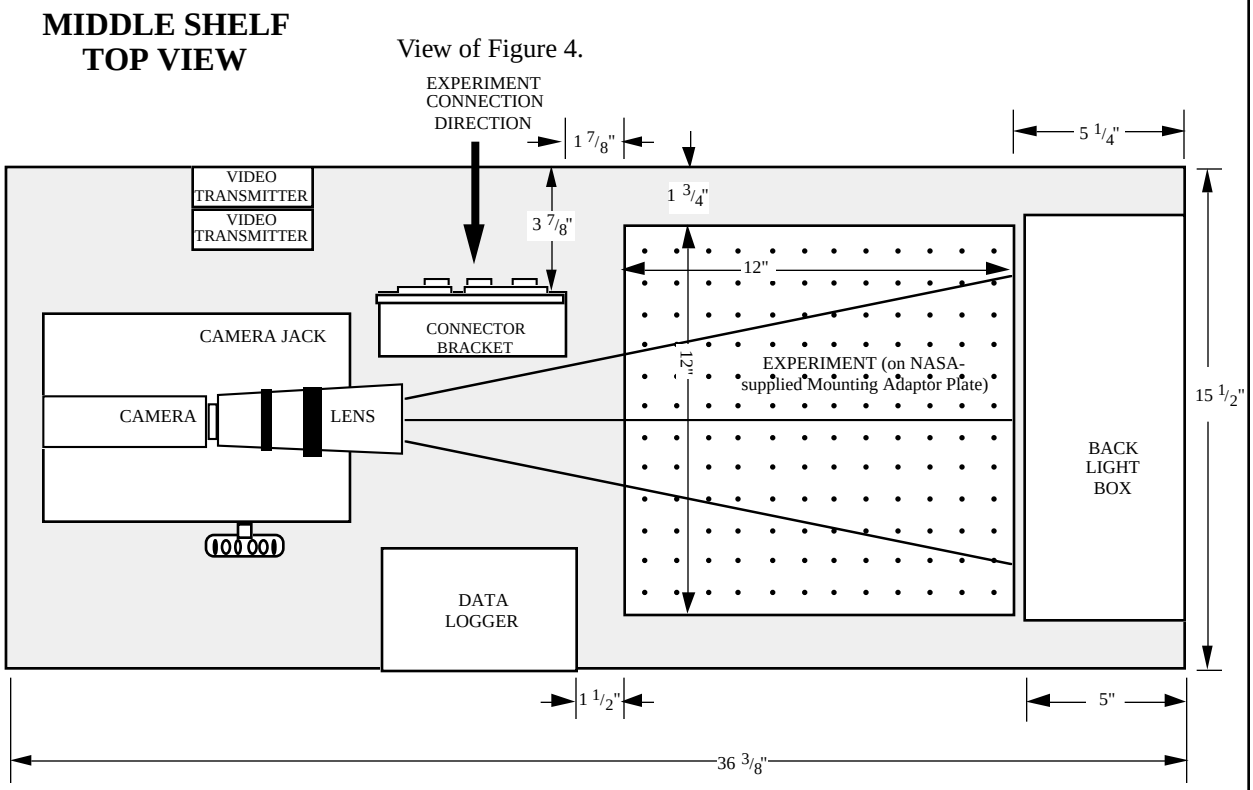


Figure 9. Education Rig middle shelf top view

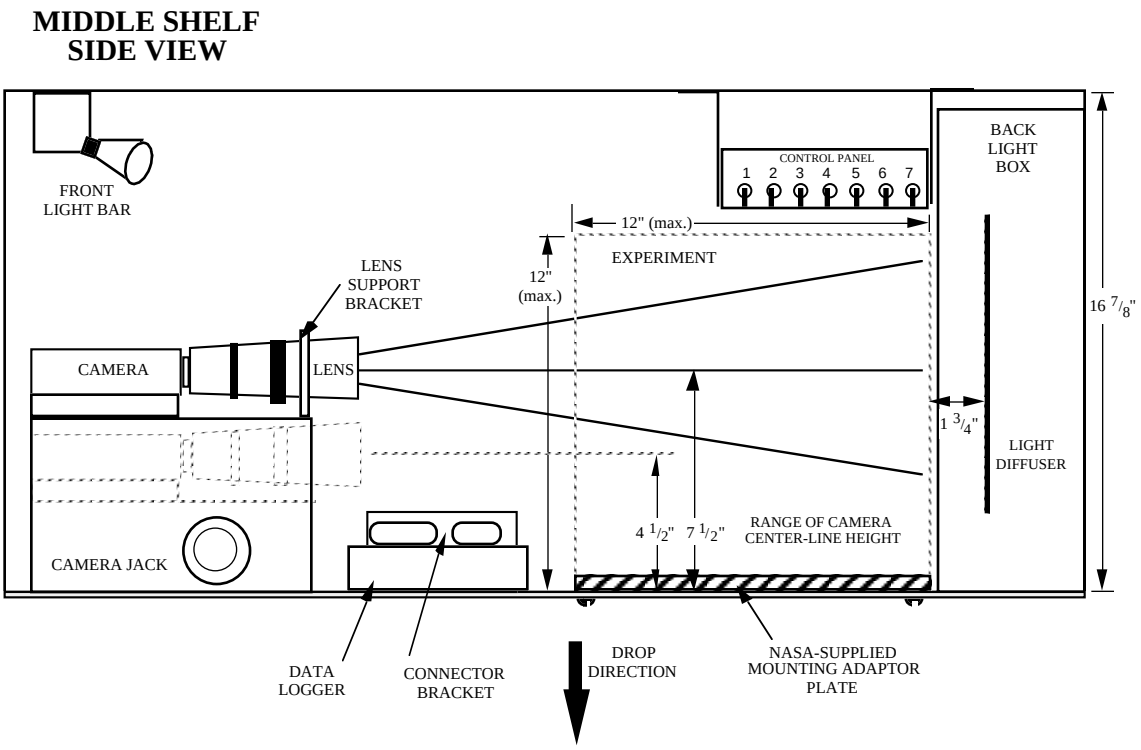


Figure 10. Education Rig middle shelf side view

10. References

1. Edmund Industrial Optics Economical Optical Bench Plates specifications for *Edmund Industrial Optics* part number 53830[1] (or equivalent):
   `http://www.edmundoptics.com/IOD/DisplayProduct.cfm?Productid=1349`
2. Valitec, Inc. data sheet for ReadyDAQ AD2000 stand-alone data acquisition system, revision 10/99
   `http://www.valitec.com/ReadyDAQ.pdf`
3. Valitec, Inc. functional diagram for ReadyDAQ AD2000 stand-alone data acquisition system, revision 9/99
4. Valitec, Inc. Operations Guide for AD128 stand-alone data acquisition system, 1999

11. Appendix: Examples of Electrical Usage on DIME Experiments

Power control before experiment is dropped

The example circuit shown in Figure 11 illustrates the use of the Power Switch Relay to control a heater in the experiment. The experiment design calls for convection to be established in a fluid chamber prior to the release. With the panel switch, the operator turns on the Power Switch Relay which provides power to the heater. The fluid chamber is observed in the video monitor and when convection has begun, the experiment is released by the drop tower operator.

The connections made between the DIME experiment and the Education Rig use connectors J1 and J3. NASA will supply the necessary electrical connectors to the DIME team for their use in constructing their experiment apparatus. This will ensure that the connectors on the experiment apparatus will match with those on the Education Rig.

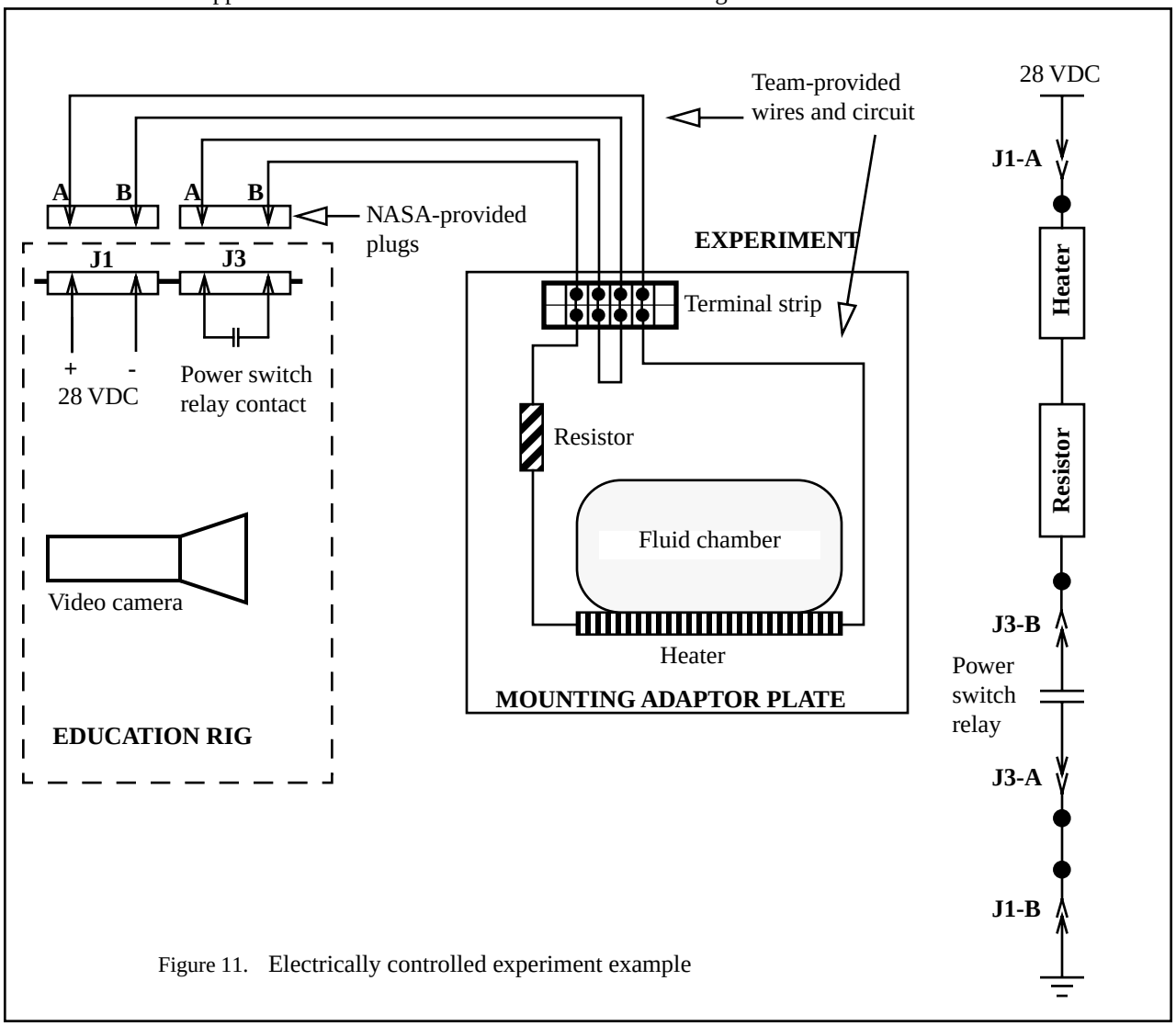


Figure 11. Electrically controlled experiment example

Measurement of mechanical motion

The example circuit shown in Figure 12 illustrates the use of the data logger to record mechanical motion. The 12 VDC is used with a 5 V voltage regulator to provide an accurate 5 V to the circuit. The shaft of the potentiometer was connected to a mechanical arm that rotated during the 2.2 seconds of free fall. The weightless detector switch was designed to open its contacts when the experiment was dropped. The voltages from the potentiometer and the weightless detector switch go to an analog input and a digital input of the data logger, respectively.

The connections made between the DIME experiment and the Education Rig use connectors J2 and J5. NASA will supply the necessary electrical connectors to the DIME team for their use in constructing their experiment apparatus. This will ensure that the connectors on the experiment apparatus will match with those on the Education Rig.

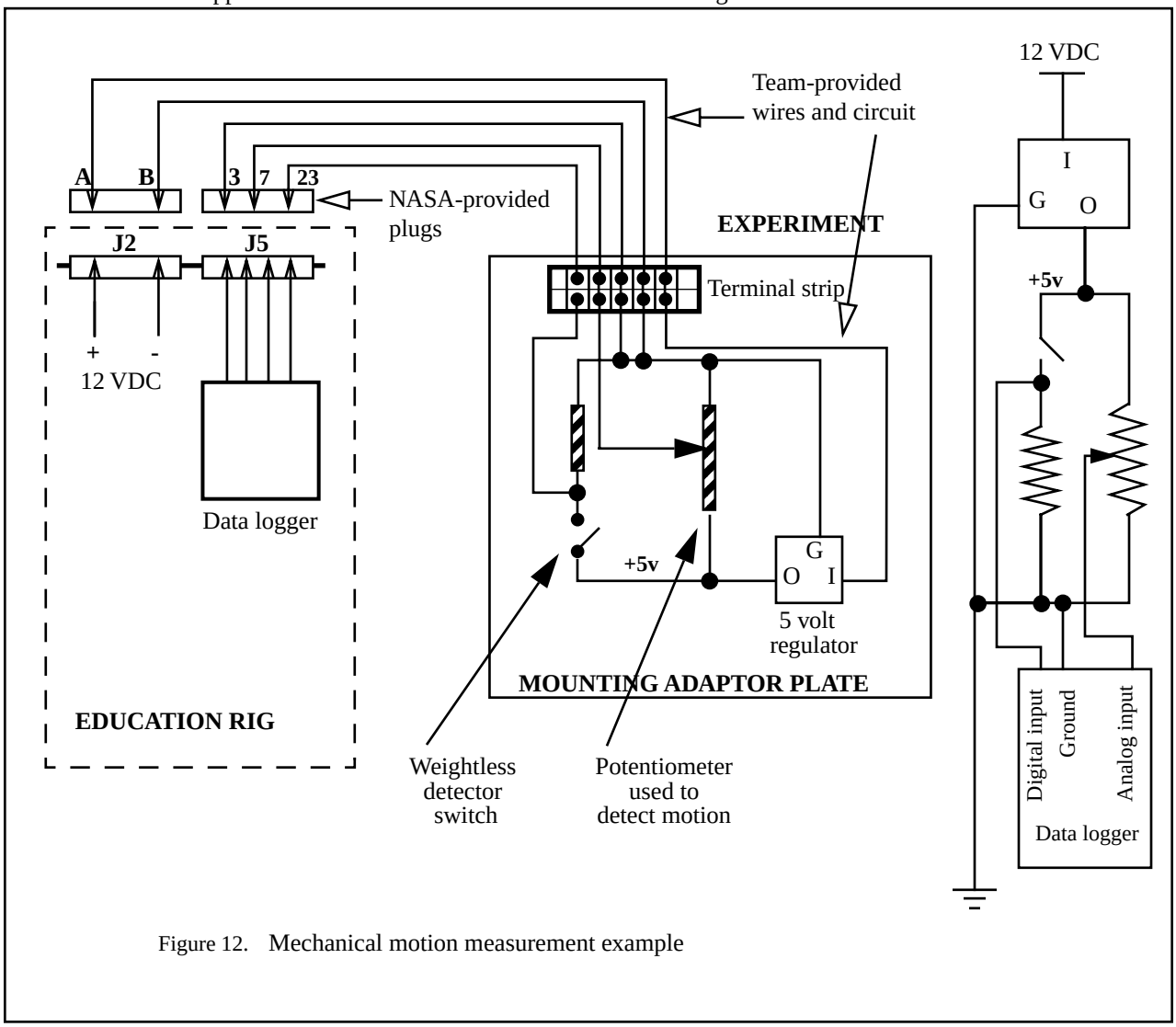


Figure 12. Mechanical motion measurement example

Acknowledgements

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- Microgravity Science Division at NASA Glenn Research Center, Cleveland, Ohio
- National Center for Microgravity Research on Fluids and Combustion at NASA Glenn Research Center, Cleveland, Ohio
- Microgravity Research Program Office at NASA Marshall Space Flight Center, Huntsville, Alabama
- Office of Biological and Physical Research at NASA Headquarters, Washington DC
- Office of Human Resources & Education at NASA Headquarters, Washington DC

The DIME program is carried out by personnel in the Microgravity Science Division and the National Center for Microgravity Research on Fluids and Combustion. Critical support also comes from the staff of the 2.2 Second Drop Tower facility and the Imaging Technology Center.

NOTE:
Use of commercial names and products does not imply an endorsement by NASA.

Documents and other information related to the DIME program may be accessed at the following World Wide Web address:

`http://microgravity.grc.nasa.gov/DIME.html`